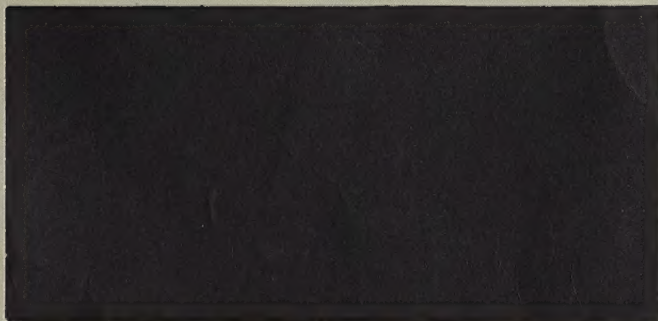
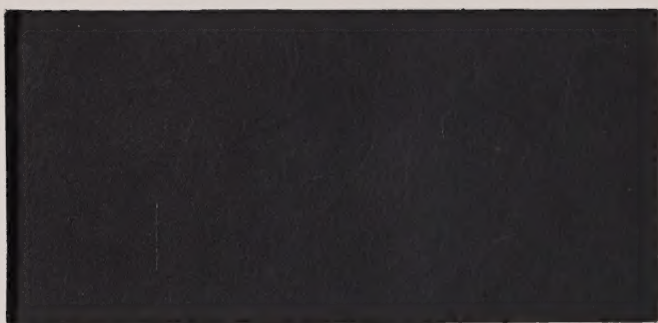




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INSTRUCTION MANUAL

980242

MODEL 2860

DATA AMPLIFIER



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August, 1967

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Dana Model 2860 is a passive-guard differential amplifier with low noise at gains up to 2500, high level of common mode rejection, and fast settling time. Full-scale output is ± 10 volts and ± 100 milliamperes.

The Model 2860 features the advantages of direct-coupled amplifiers (linearity, low zero drift, low noise) with the 300-volt common mode operating capability that is characteristic of modulation-coupled amplifiers.

A front-panel bandwidth control allows the output to be set at any one of five selected bandwidths: 10Hz, 100Hz, 1kHz, 10kHz and wideband. The minimum -3dB frequency in the wideband position is 50kHz.



Figure 1.1 - Model 2860 Data Amplifier

The input, output, and power supply of the Model 2860 contain RF interference suppression from external RF noise. The Model 2860 provides almost complete isolation between the input leads and output common. If desired, the Model 2860 may also be used as a single ended unit, inverting or non-inverting, in applications in which either the source or the load is isolated from the ground. The common-mode rejection is 120dB, dc to 60 Hz.

Circuits within the amplifier prevent damage from short circuits and from fault voltages up to 30 volts normal mode.

System noise contributed by the amplifier circuitry is exceptionally low. The noise referred to the input (RTI) at a gain of 1000 is less than 5 microvolts rms in full bandwidth and less than 1 microvolt, peak-to-peak, in a 10Hz bandwidth.

1.2 OPERATIONAL DESCRIPTION

A block diagram of the Model 2860 is shown in Figure 1.2. The Preamplifier amplifies the normal mode signal. The amplified signal is modulated and applied to the isolation transformer, demodulated, and further amplified by the Output Amplifier. The common mode potential (E_{CM}) appears between the transformer shields. The input guard or shield surrounds the Preamplifier as well as the input leads. When the guard is referenced to the common mode potential, the

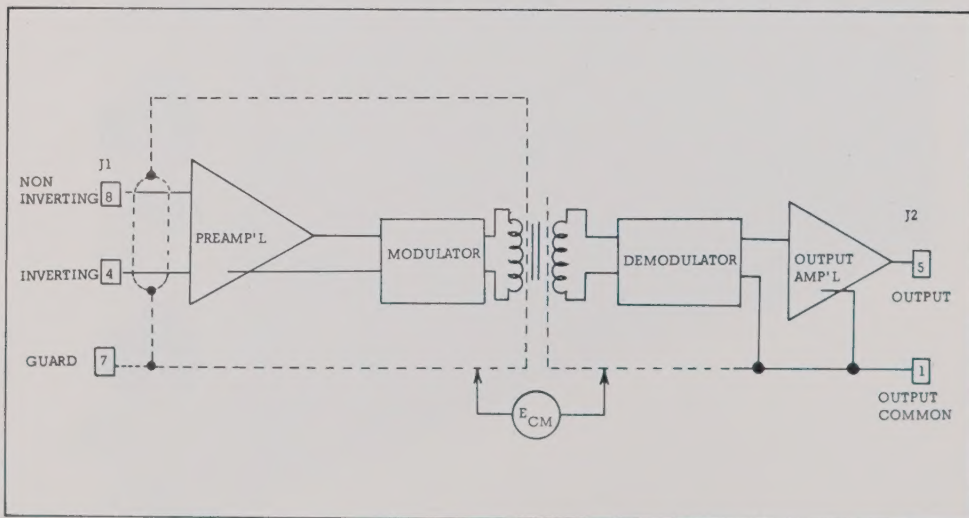


Figure 1.2 - Block Diagram, Model 2860

commonmode potential is isolated from the preamplifier achieving the high common mode rejection required for data amplifiers. The passive guard or passive shield can reject a greater magnitude of common-mode voltage than the active-guard amplifiers and is characterized by constant common mode rejection - not affected by gain setting.

The Output Amplifier contains an operational amplifier and an active-admittance amplifier. The output voltage of the Output Amplifier is ± 10 volts across a 100 ohm load.

Capacitors in the active-admittance filter are switched with each position of the BANDWIDTH switch to set the upper limit of each bandwidth.

Precision resistors in the Preamplifier are switched with each position of the GAIN switch to set the gain of the amplifier. A vernier extends each range equal to 2-1/2 times the nominal gain setting.

A more detailed description of the circuits of the Model 2860 is given in Section 4 - Circuit Description.

1.3 GAIN OPTIONS

Two gain options are available and must be specified when ordering the amplifier. They are designated as gain options V4 and V5. The Models 2860 V4 and 2860 V5 are especially suited in applications where low-level, millivolt signals are to be amplified to voltage levels for accurate recording or measuring and in applications where common mode potentials are greater than 10 volts dc or peak ac.

1.3.1 Option V4

The V4 option provides gain steps of 1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000. A vernier multiplier extends each gain by a factor of 2.5:1. Gain accuracy of the V4 option is $\pm 0.1\%$.

1.3.2 Option V5

The V5 option provides the same gain steps and vernier multiplier as the V4 option. However, the gain accuracy of the V5 option is $\pm 0.01\%$.

1.4 SPECIFICATIONS

Specifications are listed in Table 1.1.

1.5 AMPLIFIER ENCLOSURES

The 2808 Enclosure accommodates eight amplifiers. The enclosure is 7 inches in height with a depth of 22 inches and a width, including flanges, of 19 inches.

Table 1.1 - Specifications

DANA MODEL 2860 SPECIFICATIONS	
All specifications apply for 0 to 1000 ohm source, in any unbalance.	
Gain	
Range	1 to 2500 with 2.5:1 vernier
Steps	1, 2, 5, 10, 20, 50, 100, 200, 500, 1000
Accuracy	$\pm 0.01\%$ V5 option; $\pm 0.1\%$ V4 option
Resolution	$\pm 0.01\%$ ($\pm 0.03\%$ worst case)
Stability (at gain setting and constant temperature)	$\pm 0.01\%$ (200 hrs)
Temperature coefficient	$\pm 0.005\%$ / °C
Output (no damage for sustained short circuit)	
Full scale voltage	± 10 V
Voltage overrange, nominal	20%
Full scale load current	± 100 mA
Maximum short circuit current	± 150 mA (adjustable to ± 60 mA)
Impedance	0.1 ohm in series with 30 μ H
Capacitive load, without instability	Infinite
Capability	Full scale voltage and current to 50 kHz
Frequency Response (at full output)	
Wideband	
dc to 100 Hz	$\pm 0.01\%$
Minimum 3 dB frequency	50 kHz
Variband	
Filter characteristics	3 pole Bessel
Switch selectable cutoff frequencies (f_{co}) of	10 Hz, 100 Hz, 1 kHz, 10 kHz, wideband
Attenuation at selected f_{co}	-3 dB ± 1 dB
Attenuation above selected f_{co}	-60 dB/decade
Linearity	
dc to 2 kHz	$\pm 0.01\%$
Common Mode	
Rejection ratio at dc	140 dB
Rejection ratio dc to 60 Hz	120 dB
Operating voltage dc to 60 Hz	300 V dc or peak ac
Fault voltage dc to 60 Hz without damage	300 V dc or peak ac
Noise	
Full bandwidth	3 μ V rms RTI + 2 mV rms RTO
10 kHz bandwidth	1 μ V rms RTI + 1 mV rms RTO
10 Hz bandwidth	1 mV peak to peak RTO, for any gain
Input Impedance	
Normal mode	10,000 M Ω , parallel with 0.001 μ F
Zero Stability	
At constant temperature (after 30 minute warm-up)	$\pm 0.02\%$ (200 hrs)
Temperature coefficient	($\pm 0.002\%$ RTO ± 1 μ V RTI) / °C and ± 0.5 nA RTI / °C
Step Function Response	
Settles to final value $\pm 0.01\%$ of full scale in	$175 \mu\text{sec} + \frac{1.6 \text{ sec}}{f_{co}}$
Overload Recovery	
Settles to final value $\pm 0.01\%$ of full scale for 5 times full scale input for gains of 5 to 2500 or 10 V for gains of 1 to 5 in	$400 \mu\text{sec} + \frac{1.6 \text{ sec}}{f_{co}}$
No damage for 30 V dc or peak ac input on any gain	
Temperature Range	
Operating	0°C to +50°C
Storage	-20°C to +75°C
Power Requirement	
Domestic	105 to 125 V rms, 50 to 400 Hz, 10 watts
Export Option 1	200 to 240 V rms, 50 to 400 Hz, 10 watts
Export Option 2	215 to 265 V rms, 50 to 400 Hz, 10 watts
Export Option 3	90 to 110 V rms, 50 to 400 Hz, 10 watts
Enclosure	
Model	2808-1 or 2808-2
Capacity	8 amplifiers fit in a standard 7 inch by 19 inch panel space
Bench Operation	
Model	2801 single unit adapter

The basic model is modified by a "dash" number which specifies the type of wiring.

The 2808 Enclosure accommodates all of the Dana Series 2800 Amplifiers. The amplifiers are interchangeable in the enclosure without alteration of the input and output cables.

The -1 Enclosure contains connectors to accommodate system wiring. Fusing and AC wiring are factorywired. An outline drawing (452402) is included in Section 6, "Drawings and Parts Lists".

The -2 Enclosure is fully wired. The inputs and outputs are accessible through connectors mounted on the rear panel. An outline drawing (452403) is included in Section 6, "Drawings and Parts Lists".

Wiring instructions for each type enclosure are included in Section 2, "Installation".

1.6 AMPLIFIER ACCESSORIES

An Adapter Set Model 2801 (Dana part number 402468) and an Amplifier Support Bracket (Dana part number 452411) are used when the amplifier is operated on the bench. The Adapter Set (item 1 in Figure 1.3) contains input leads, output leads, and the power cord. The Amplifier Support Bracket (item 2 in Figure 1.3) mounts to the amplifier to support the amplifier in an upright position.

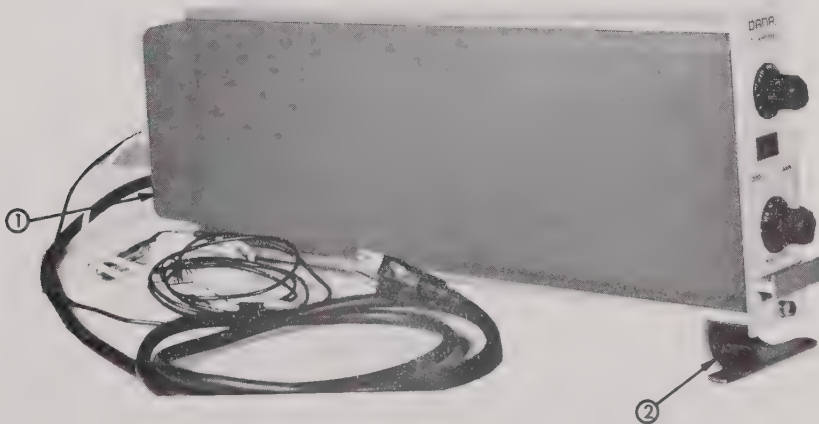


Figure 1.3 - Amplifier Accessories

SECTION 2

INSTALLATION AND INITIAL CHECKOUT

2.1 UNPACKING AND INSPECTION

The Dana Amplifier is shipped in a special reusable shipping package, designed to protect the instrument from excessive shock and vibration. Examine the package for signs of external damage before removing the unit. If external damage is present, notify the carrier before proceeding. Next, examine the outside of the amplifier for any evidence of damage due to excessive shock, vibration, water leakage, etc.

If the unit appears in perfect condition, proceed with the installation. However, if there is any apparent damage, communicate with the carrier for instructions.

2.2 POWER REQUIREMENTS

Dana Amplifiers, manufactured for domestic use, operate on 115 volts (± 10 volts), 50 to 400 Hz. Units manufactured for export operate on 210 to 250 volts, 50 to 400 Hz. Power required is eight watts.

NOTE

If the Amplifier has been stored for a prolonged period (5 or 6 months) without use, it is recommended that it be operated with a variable transformer, such as a Variac, at one-half line voltage for about two hours before gradually applying full power. This is done to "reform" the electrolytic capacitors in the amplifier and reduce the chance of capacitor failure.

2.3 INPUT - OUTPUT CONNECTIONS

Input and output connections to the amplifier are through an eight pin connector (J1) at the rear of the amplifier (see Figure 2.1). External connections are brought in through a mating connector. When the Dana enclosures are used, the mating connector for each amplifier is mounted on the inside back panel of the enclosure; each amplifier plugs into its corresponding connectors. When amplifiers are used singly, a single unit adapter set is normally used. The adapter set (Dana part number 402468) includes the mating connector, power cord, and clip leads for input and output signal connections.

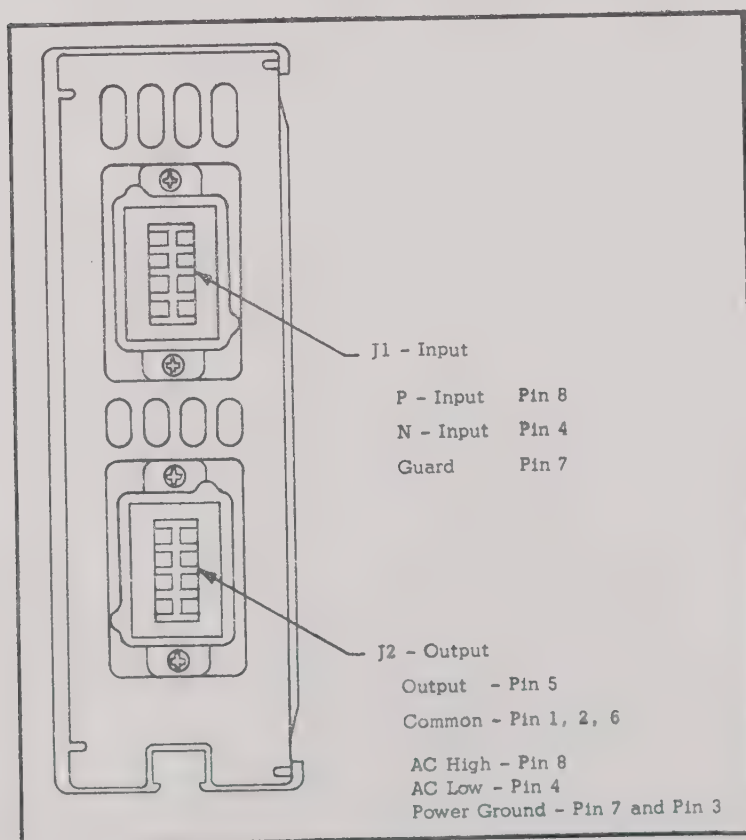
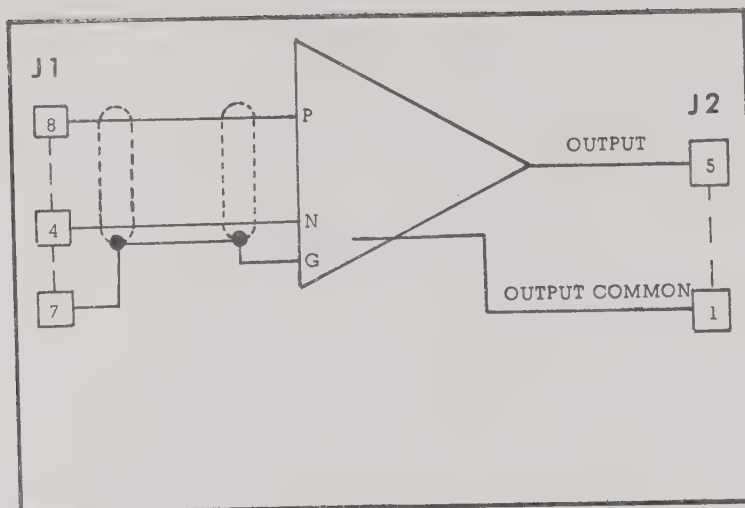


Figure 2.1 - Input/Output Connections

When the 2808-1 Enclosure is used, external connections are made directly to the solder side of the enclosure mounted connector for each amplifier. Access to connectors is gained by removing four screws holding the rear panel and allowing the top of the rear panel to drop away from the enclosure. External leads are routed through the grommet holes and soldered to the connectors.

In the 2808-2 Enclosure, conventional cable connectors are mounted on the rear panel. Connections are made by wiring to the mating connector. All pin connections are identified in Figure 2.2.

2.3.2 Power

When the Amplifier is to be operated within the 2808-1 or 2808-2 Enclosure, power is prewired and a three-wire line cord is supplied. When using the cord set, power and input/output connections are prewired. The power cord is connected to P2 of the cord set.

The ground wire of the power cord connects to the internal power supply shield of the amplifiers.

2.3.3 Input/Output Signals

Input wiring configurations are extremely important in minimizing common mode voltages. The guard lead should be connected as close as possible to the signal source. Input and output connections are shown in Figure 2.2.

For permanent installations, low thermal solder (70% cadmium, 30% tin) should be used for all input connections to reduce thermocouple errors. For temporary or test setups, screw terminals or clips having low resistance may be used, taking suitable care to minimize thermal emf's (a few microvolts can be significant on high gain ranges).

Since P and N inputs to the amplifier are symmetrical (approximately equal impedance to output common), either lead may be connected to either side of the signal source. For phasing purposes, if P is positive with respect to N, the output is positive with respect to output common.

Input leads should be two-conductor in an insulated shielded cable (Belden #8451-500, or equivalent). The shield must be soldered to the guard pin connection (pin 7 of J1 when a -1 Enclosure is used; pin B of the signal input connector for a -2 Enclosure). The unshielded portion of the leads must be kept as short as possible.

A single-conductor shielded cable is recommended for output leads. If two-conductor is used, connect one lead and shield together at either end or both ends. Solder the shield to Output Common (pin 1 of J2 for -1 enclosures; see Figure 2.1 for -2 enclosures). The enclosure chassis is connected to ground by the power cable. The lead from the output common terminal of the amplifier should be connected directly to the input common or ground of the output device.

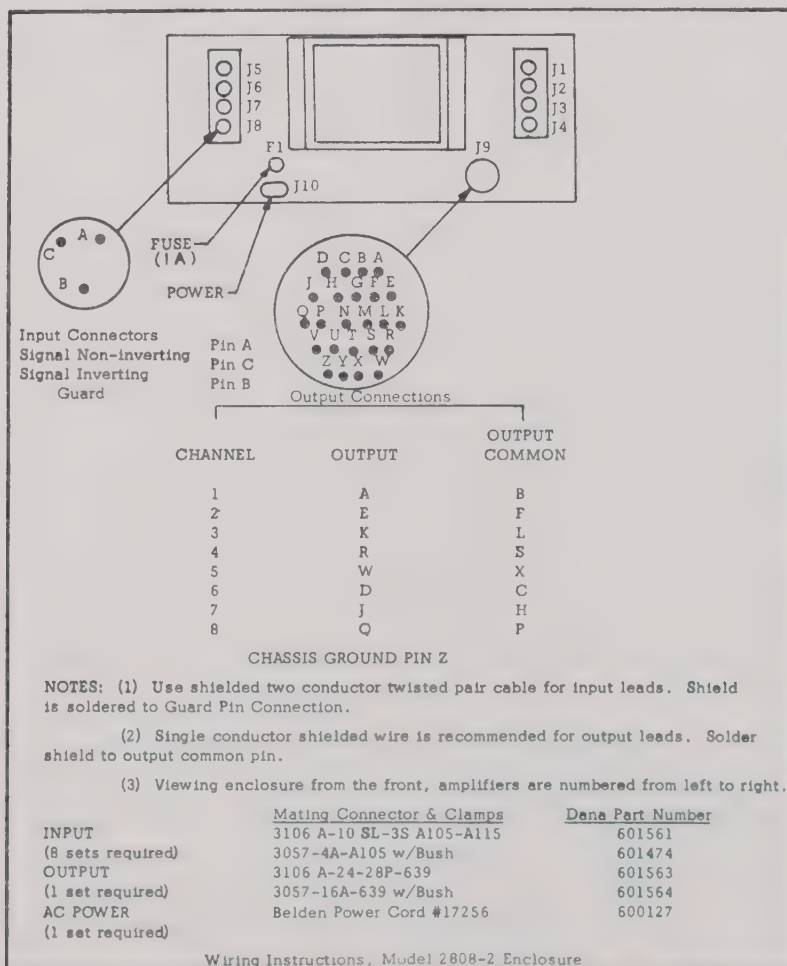
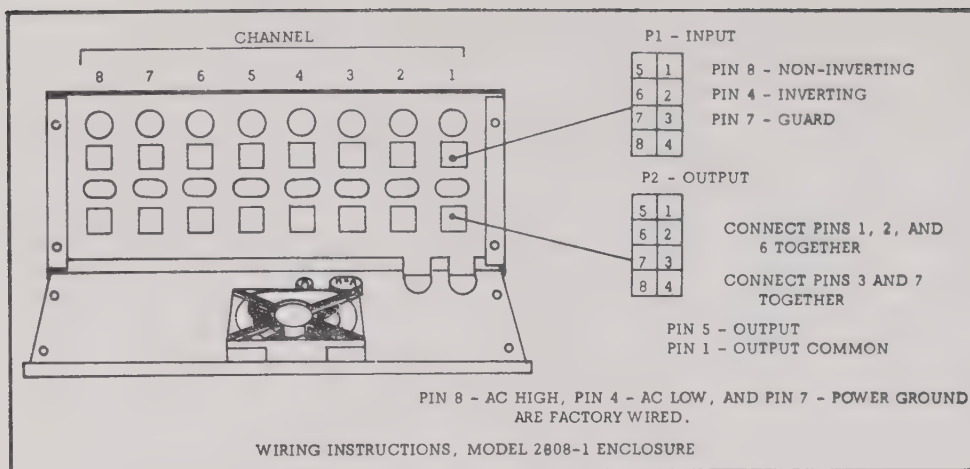


Figure 2.2 - Enclosure Wiring

2.4 INITIAL CHECKOUT PROCEDURES

The amplifier is accurately adjusted and carefully inspected at the factory. The following tests check basic characteristics of the amplifier to verify proper operation upon delivery. The type of damage that can be expected in shipment tends to produce gross malfunctions rather than minor changes in sensitive characteristics. More complete and precise tests and calibration procedures are included in Section 5, "Calibration".

Only three items of test equipment are required to perform initial checkout of the amplifier:

- Audio Oscillator
- Voltage Divider/Attenuator
- Oscilloscope

Standard laboratory-type instruments from any manufacturer may be used.

2.4.1 Gain Checkout

1. Connect the common or ground terminals of each item of test equipment to a single point and to the amplifier output common (pin 1 of J2). Connect this point to ground. Make all measurements relative to this point (see Figure 2.3).

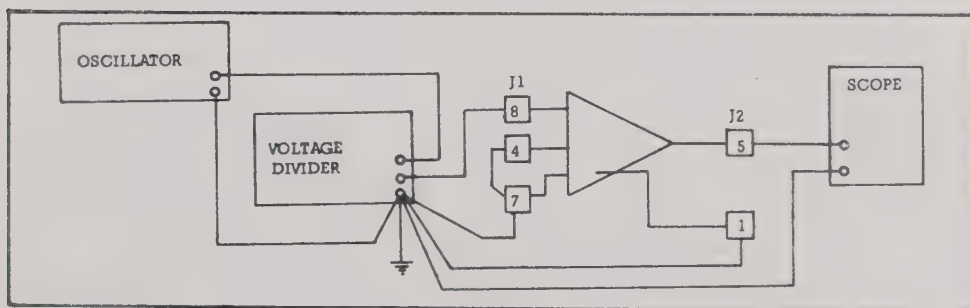


Figure 2.3 - Gain Test Setup

2. Set voltage divider to minimum output — zero, if possible.
3. Apply power to amplifier. Observe amplifier output on oscilloscope. It should be within a few millivolts of ground and change only very slightly as the amplifier GAIN switch is rotated.
4. Set the VERNIER gain adjustment fully counterclockwise.
5. Set the GAIN selector switch at the highest gain position.
6. Remove scope lead from amplifier output and connect scope to the oscillator output. Adjust oscillator for 20 volts, peak-to-peak, at 100 Hz.
7. Set voltage divider to the reciprocal of the maximum gain setting, 1/K. (For example, at maximum gain of 1000, set divider to 0.001.)
8. Return the scope to the amplifier output, pin 5 of J2. The scope should now indicate approximately the same value, 20 volts peak-to-peak, observed at the oscillator output. (The term "approximately" is used because of the limited capability of an oscilloscope to compare two magnitudes accurately.)
9. Verify that there is no obvious noise or other unexplained distortions on the oscilloscope trace.

2.4.2 Frequency Response Checkout

1. Use test setup exactly as connected for Gain checkout. Set amplifier GAIN control at maximum; vernier adjustment to minimum. Connect scope to oscillator output; set oscillator frequency to 50 kHz. Set the BANDWIDTH switch to the WB(wideband) position.
2. Set oscillator output at 20 volts, peak-to-peak (on scope).
3. Remove scope lead from oscillator and connect to amplifier output pin 5 of J2. Adjust voltage divider for amplifier output amplitude equal to that observed in step 2.
4. Compare voltage divider setting with zero — or minimum output position. The difference should be no less than 3dB, or approximately 30%.

2.4.3 Common Mode Rejection

1. Short the amplifier input leads and the input guard lead (pins 8, 4, and 7 of J1). Connect these leads to the high side of a signal generator.
2. Connect oscilloscope to amplifier output (pin 5 of J2).
3. Set oscillator output to 20 volts, peak-to-peak, at 60 Hz.
4. Set amplifier GAIN switch to 1000.
5. Observe amplifier output on scope. The output due to common mode is normally not detectable above the wideband noise of the amplifier. Common mode rejection can be calculated as follows:

$$\text{CMR} = \frac{20 \text{ Volts (P-P)} \times K}{\text{Output Voltage (P-P)}}$$

SECTION 3

OPERATION

3.1 CONTROLS

3.1.1 Gain Selector Switch

The GAIN switch is rotated to select the desired gain of the amplifier. One of ten gain positions may be selected. The selected gain is inscribed on the knob of the gain selector switch.

3.1.2 Bandwidth Switch

The BANDWIDTH switch allows selection of the amplifier bandwidth. It is calibrated in kilohertz and has the following positions:

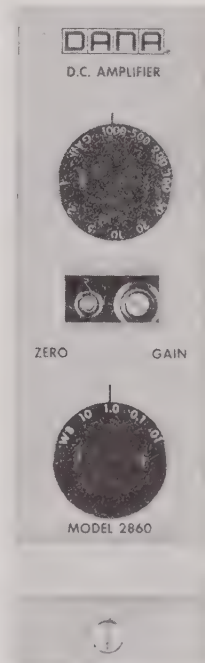
Switch Position	Bandwidth
0.01	DC to 10Hz
0.1	DC to 100Hz
1.0	DC to 1000Hz
10.0	DC to 10kHz
Wideband (WB)	Full Bandwidth

3.2 OPERATIONAL ADJUSTMENTS

3.2.1 ZERO Adjustment

ZERO is a screwdriver adjustment on the front panel of the amplifier. It is used to set the output voltage to zero volts with no input. It is adjusted in the following manner:

1. Apply power to the amplifier and any adjoining heat-producing equipment and allow amplifier to stabilize (approximately 30 minutes).
2. Set GAIN selector switch to lowest gain position.
3. Return the input P(J1-8) and N(J1-4) leads to output common (J2-1).
4. Connect voltmeter or scope to amplifier output (J2-5) and common (J2-1).



Model 2860

5. Adjust ZERO for zero amplifier output. Counterclockwise rotation corrects for a positive output; clockwise rotation corrects for a negative output.

3.2.2 GAIN Adjustment

This is a screwdriver adjustment which serves as a vernier adjustment of gain selected by the GAIN selector switch. The adjustment varies each gain position by a factor of 2.5:1 — providing continuous gain selection throughout all available ranges.

3.3 OPERATING PROCEDURES

After installation of the amplifier as described in Section 2, operation consists simply of selecting the appropriate gain. The amplifier is ready for use immediately with zero stability achieved within 30 minutes.

SECTION 4

CIRCUIT DESCRIPTION

4.1 INTRODUCTION

A block diagram of the Model 2860 amplifier is shown in Figure 4.1. The forward loop consists of the preamplifier, isolator, and output amplifier. The preamplifier amplifies the potential difference between the two inputs e_1 , e_2 . The output of the amplifier is proportional to the difference of the amplitudes. These signals are referred to as "normal mode signal" (also referred to as "difference" or differential signals). The potentials common to both inputs are referred to as "common mode potentials" and are physically isolated from the preamplifier by a mechanical enclosure.

The normal mode signals are defined as

$$\text{Normal Mode Signal} = e_2 - e_1$$

$$\text{Output } (E_o) = (e_2 - e_1) (\text{Gain})$$

In single ended operation, a signal is applied to e_2 while e_1 is common; therefore, the output is proportional to the amplitude of the one signal applied.

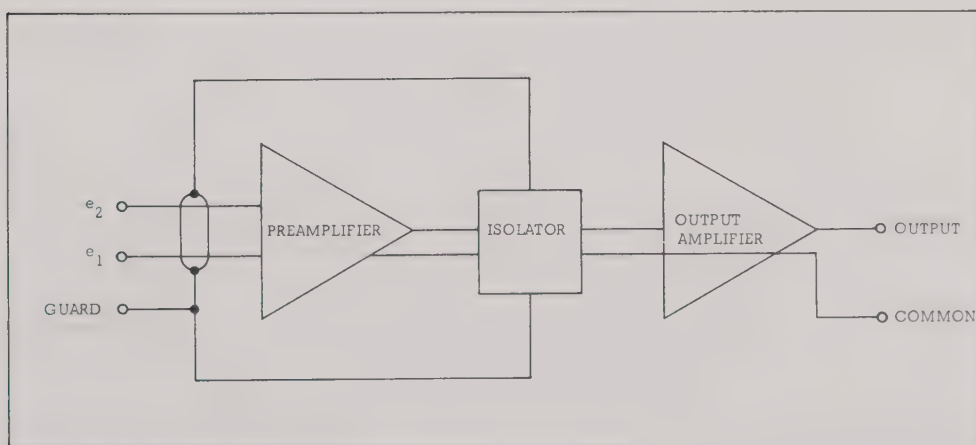


Figure 4.1 - Block Diagram, Model 2860 Amplifier

4.2 PREAMPLIFIER

The Preamplifier is shown in Figure 4.2. The normal mode signals are converted into current and applied to the isolator. The gain resistor (R_G) scales the input voltage such that the full scale current (i) to the isolator is 1 milliampere for all possible full scale input signals (10 millivolts to 10 volts). The required resistor R_G is switched into the circuit by the GAIN switch on the front panel. Values of R_G range from 10 ohms to 10,000 ohms according to the relation

$$R_G = \frac{e_2 - e_1}{1 \text{ milliampere}}$$

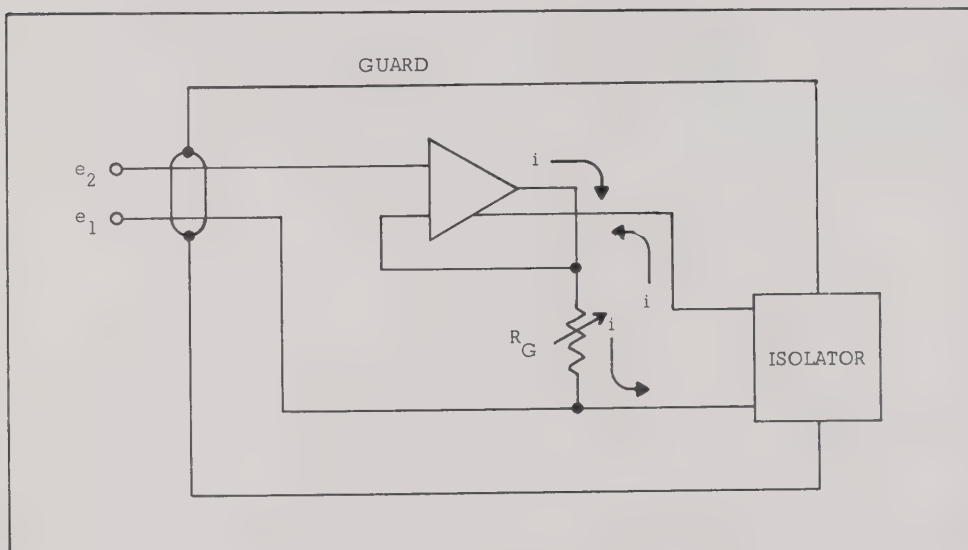


Figure 4.2 - Preamplifier

4.3 ISOLATOR

The Isolator contains a transformer, a modulator, and a demodulator as shown in Figure 4.3. The current enters the primary winding of the transformer from the preamplifier, is modulated, and coupled to the secondary winding of the transformer where it is demodulated in the demodulator section of the isolator. The modulator and demodulator are synchronized from the same source for the proper phasing of the signal. An astable multivibrator provides the switching source to the modulator switches and the demodulator switches as shown in Figure 4.4.

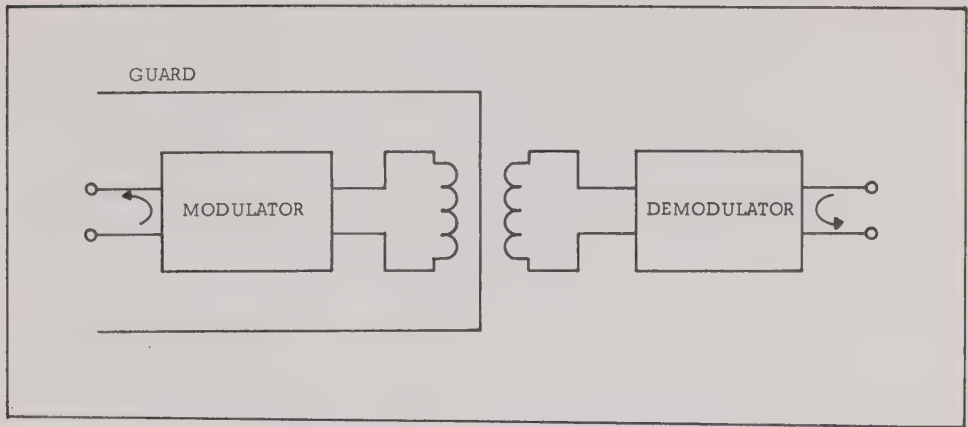


Figure 4.3 - Isolator

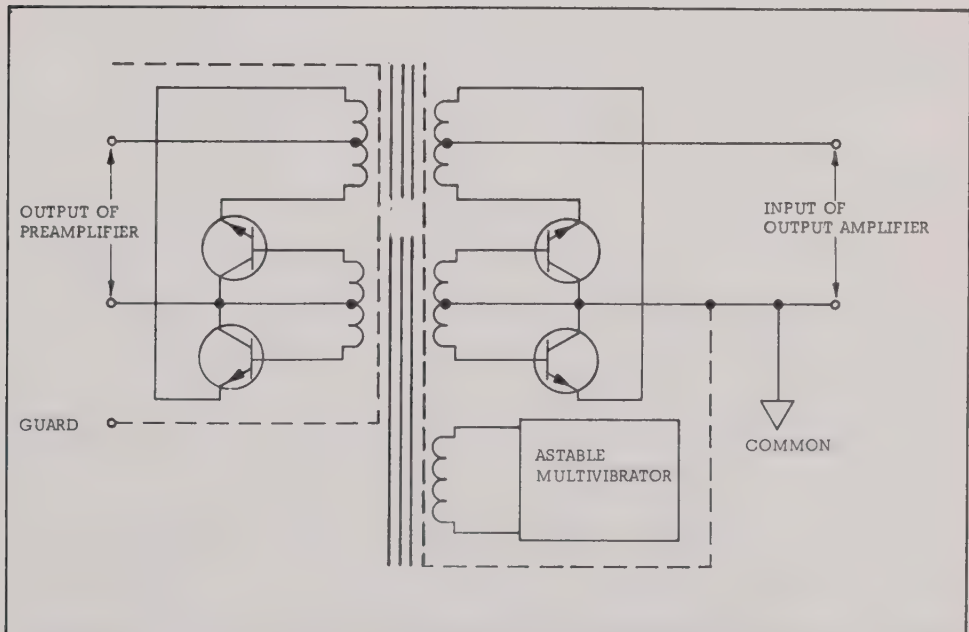


Figure 4.4 - Modulator and Demodulator

4.4 OUTPUT AMPLIFIER

The Output Amplifier (Figure 4.5) consists of an operational amplifier, active-admittance filter, and buffer amplifier. A negative feedback trim potentiometer is the vernier gain adjust for the amplifier. Current at the input is converted to voltage at the output. The active-admittance filter is a three pole Bessel filter consisting of a resistor R_1 and an active filter (Y) that attenuates the signal 3dB at the selected cutoff frequency (front panel BANDWIDTH control). Attenuation above the cutoff frequency is 18dB per octave, 60dB per decade. The buffer amplifier is a unity gain amplifier that provides ± 100 milliamperes to a load of 100 ohms.

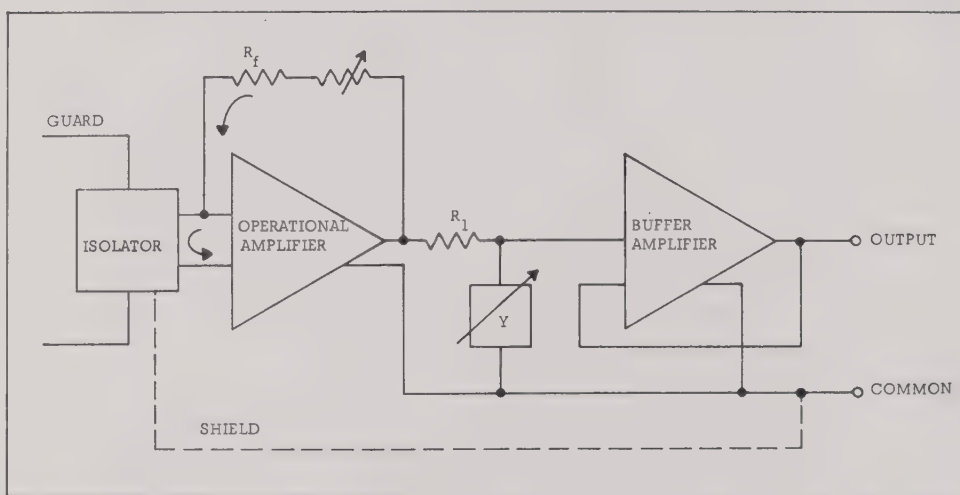


Figure 4.5 - Output Amplifier

SECTION 5

CALIBRATION

5.1 TEST EQUIPMENT

1. OSCILLOSCOPE - X-Y inputs; bandpass, DC - 500 kHz; calibrated deflection factors of 1 millivolt to 20 volts per centimeter accurate within 3%; input impedance, 1 megohm paralleled by less than 50pf.
2. OSCILLATOR - Frequency range, 5 Hz-500kHz; accuracy, $\pm 2\%$; frequency response, ± 1 dB; adjustable output voltage, 160 milliwatts (10 volts) into 600 ohms rated load, 20 volts open circuit.
3. VACUUM TUBE VOLTMETER - Voltage range, 0.1 millivolt to 300 volts; dB range, -72 to +52dB; frequency range, 10 Hz to 1 MHz accurate within $\pm 2\%$ (50Hz - 500 kHz); input impedance, 10 megohms paralleled by less than 50pf.
4. ATTENUATOR - Attenuation to 120dB in 1dB steps; DC to 1 MHz accurate within ± 1 dB; power capacity, 5 watts.
5. DC MILLIVOLTMETER (Optional)
6. Dana Adapter Set 2801 (P/N 402468).

5.2 CALIBRATION PROCEDURES

Certain performance characteristics should be checked periodically and internal adjustments made as required. These adjustments are detailed in paragraph 5-4 - Field Calibration.

The Calibration procedure in paragraph 5.5, Major Calibration, should be performed after repair of the instrument.

5.3 FIELD CALIBRATION

Physical location of the adjustable components is shown in Figure 5.1. The procedure below should be performed in the order listed.

NOTE: Common mode potentials appear between the guard box and chassis; therefore, an insulated screwdriver or adjustment tool (J.F.D Adjustment Tool 5284) should be used to make the adjustments.

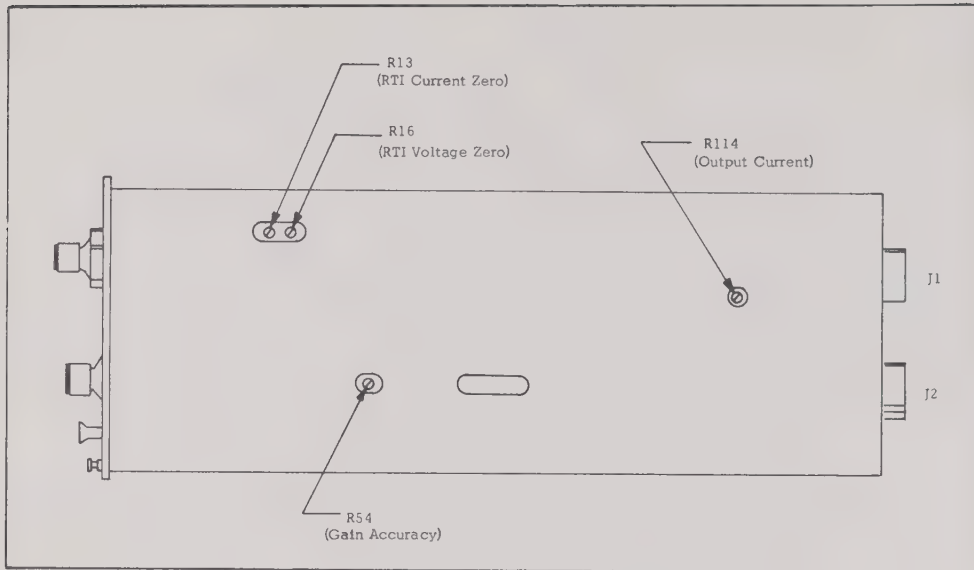


Figure 5.1 - Amplifier Adjustments, Physical Location

5.3.1 Referred to Input (RTI) Voltage Zero

In addition to the operational ZERO adjustment on the front panel, the amplifier is equipped with an internal zero adjustment (R16). Procedure for making the adjustment is as follows:

1. Connect amplifier inputs P(J1-8), N(J1-4), and guard (J1-7) together.
2. Connect an oscilloscope or millivoltmeter to output (J2-5) and common (J2-1).
3. Set the front panel GAIN vernier (R55) fully counterclockwise.
4. Set the GAIN switch to the gain of 1; adjust the front panel ZERO adjustment (R60) for minimum reading on the millivoltmeter. Record any residual offset.
5. Set the amplifier GAIN switch to the gain of 1000; adjust the internal collector zero adjustment (R16) for the same offset recorded in step 4.
6. Repeat steps 4 and 5 until the output remains the same on both the highest and lowest gain settings.

5.3.2 Referred to Input (RTI) Current Zero

This adjustment minimizes current flow through the input terminals. For most accurate adjustment, the following procedure should be performed after the RTI Voltage zero adjustment.

1. Set amplifier GAIN switch to the gain of 1000.
2. Connect input terminals P(J1-8), N(J1-4), and guard (J1-7) together.
3. Set the front panel GAIN vernier (R55) fully counterclockwise.
4. Connect oscilloscope to output (J2-5) and common (J2-1). Set vertical deflection to 1mV/cm. Record amplitude of offset voltage at output.
5. Disconnect P(J1-8) terminal from N(J1-4) and guard (J1-7), insert 1K resistor in series and reconnect to N(J1-4) and guard (J1-7).
6. Adjust R13, the base current zero control, for the same offset recorded in step 4.

5.3.3 Gain Accuracy Adjustment

The gain trim adjustment sets the gain accuracy of the amplifier. The gain accuracy for the V4 option is $\pm 0.1\%$, the gain accuracy for the V5 option is $\pm 0.01\%$.

1. Connect the test setup shown in Figure 5.2.

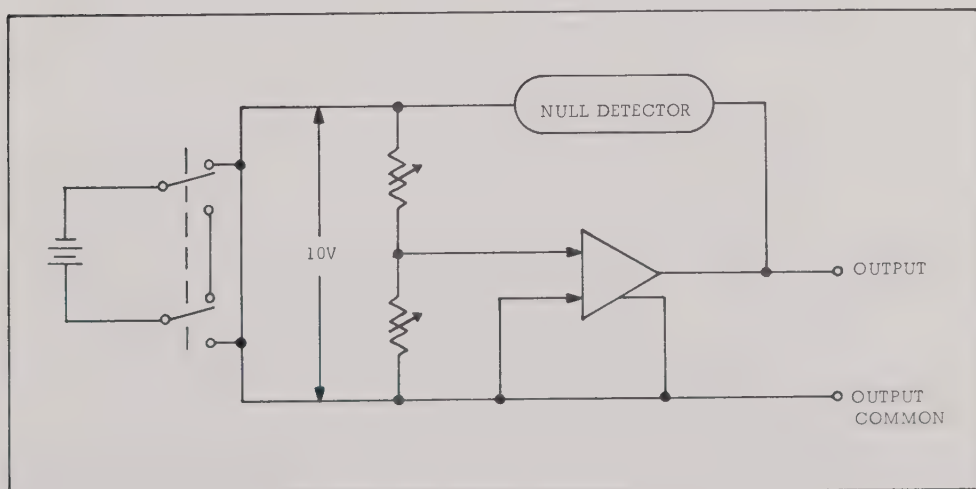


Figure 5.2 - Gain Accuracy Adjustment

2. Set the vernier gain adjustment on the front panel of the amplifier fully counterclockwise.
3. Set the GAIN selector switch of the amplifier to the gain of 100.
4. Set voltage divider* to the reciprocal of gain setting, $1/k$. (For the gain of 100, set the voltage divider to 0.01).
5. Adjust the gain trim (R54) for null. For V4 option, adjust for ± 10 millivolts; for V5 option, adjust for ± 1 millivolt.

5.3.4 Current Limit Adjustment

Potentiometer R114 adjusts the output current. The current should be limited to protect the recording device; however, the current can be limited to 100 milliamperes into a 10 ohm load.

1. Connect a 10 volt power supply, a 10 ohm 1/2 watt load resistor, and a DC voltmeter as shown in Figure 5.3.
2. Adjust R114 until the voltmeter reads 1.0 volts $\pm 10\%$.

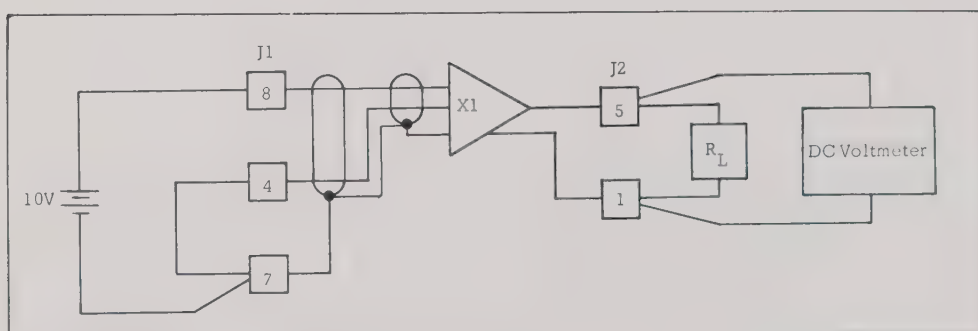


Figure 5.3 - Test Setup, Current Limit Adjust

*The gain accuracy of the amplifier can be no greater than the accuracy of the voltage divider used.

5.4 MAJOR CALIBRATION

Disassemble the amplifier per paragraph 5.5.

5.4.1 Output Amplifier Zero Adjustment

Potentiometer R67 (reference assembly drawing 402473) adjusts the zero of the output amplifier.

1. Apply power to the amplifier and allow 30 minutes for warm-up.
2. Connect terminal E60 (reference assembly drawing 402473) to output common (pin 1 of connector J2).
3. Connect an oscilloscope or millivoltmeter to output (pin 5 of connector J2) and output common (pin 1 of connector J2).
4. Set the front panel GAIN vernier (R55) full counterclockwise.
5. Adjust potentiometer R67 (reference assembly drawing 402473) for ± 5 volts.
6. Remove the common connection from terminal E60; connect terminal E61 to common.
7. Adjust potentiometer R52 (reference assembly drawing 402473) for zero volts ± 200 microvolts.
8. Remove the common connection to terminal E61.

5.4.2 Referenced to Output (RTO) Zero Adjustment

1. Connect the P(J1-8), N(J1-4), and guard (J1-7) leads together.
2. Place the GAIN switch to the gain of 1.
3. Connect a millivoltmeter to output (J2-5) and output common (J2-1).
4. Set the front panel GAIN vernier (R55) fully counterclockwise.
5. Set the front panel ZERO (R60) for zero volts ± 500 microvolts; record this voltage for further reference.
6. Set the front panel GAIN vernier (R55) fully clockwise; adjust potentiometer R52 (reference assembly drawing 402473) for the same value recorded in step 5.

7. Set the front panel GAIN vernier (R55) fully counterclockwise. The offset voltage should be the same as the voltage recorded in step 5.

8. Repeat steps 4 through 7 until the offset voltage remains the same.

5.4.3 Referred to Input (RTI) Voltage Zero Adjustments

Perform the calibration procedure in paragraph 5.3.1.

5.4.4 Referred to Input (RTI) Current Zero Adjustment

Perform the calibration procedure in paragraph 5.3.2.

5.4.5 Gain Accuracy Adjustment

Perform the calibration procedure in paragraph 5.3.3.

5.4.6 Current Limit Adjustment

Perform the calibration procedure in paragraph 5.3.4.

5.5 AMPLIFIER DISASSEMBLY

Remove eight, number 6, Phillips flat-head screws from the aluminum support (right-hand side of the amplifier as viewed from the front panel.)

To remove the cover, place the amplifier in the left hand and pull the cover toward the rear of the amplifier as shown in Figure 5.4a.

To remove the aluminum support, remove six, number 4, Phillips pan-head screws holding the circuit board assembly to the aluminum support. Three screws are at the top of the circuit board assembly; the other three screws are at the bottom of the circuit board assembly. Place the amplifier in the left hand and push the circuit board assembly as shown in Figure 5.4b.



Figure 5.4a

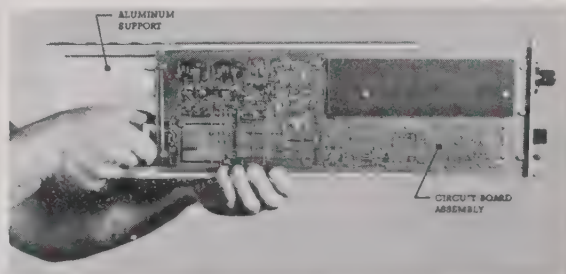


Figure 5.4b

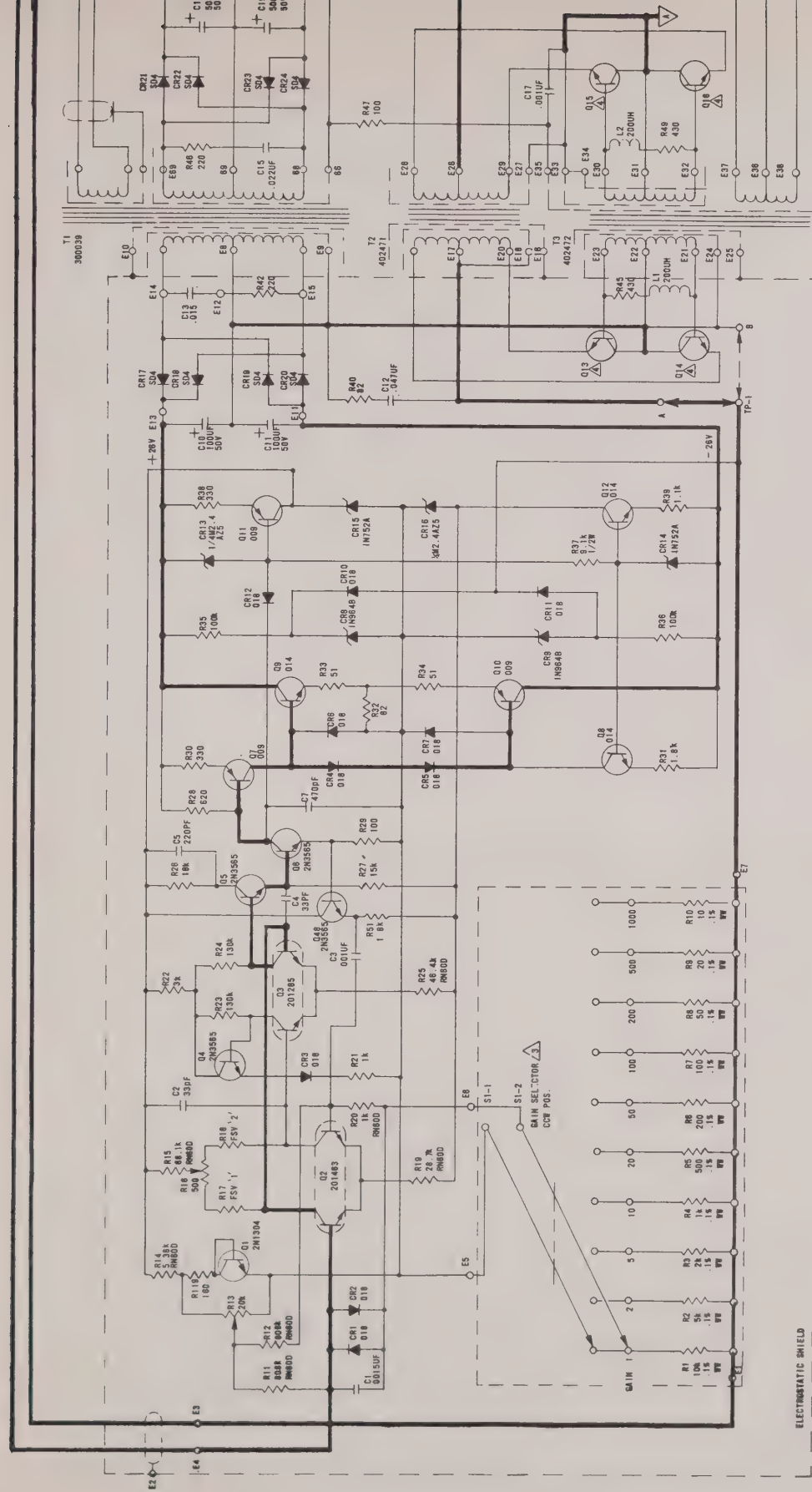
SECTION 6

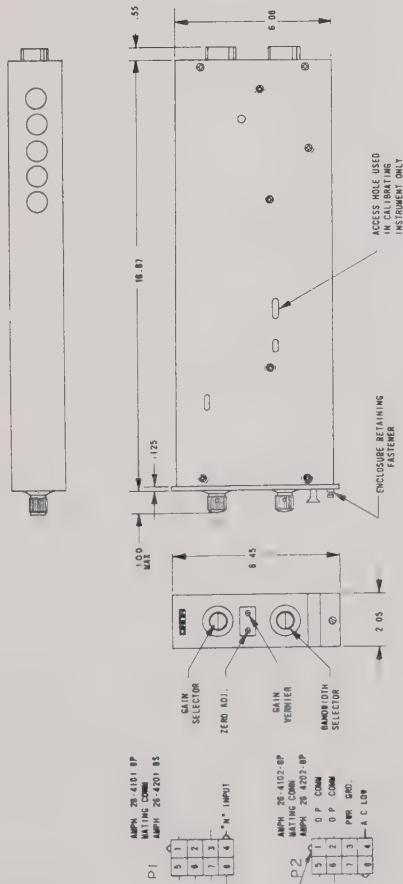
DRAWINGS AND PARTS LISTS

6.1 DRAWINGS

PCB Assembly - Model 2860	402473
Schematic - Model 2860	430654
Dimensional Outline - Model 2860	452648
Dimensional Outline - Enclosure Model 2808-1	452402
Dimensional Outline - Enclosure Model 2808-2	452403

ITEM NO.	PART NO.	DESCRIPTION
C24	120136	150UF
C25	120137	150UF
C26	120138	200UF
C27	120139	300UF
C28	120140	400UF
C29	120141	500UF
C30	120142	600UF
C31	120143	700UF
C32	120144	800UF
C33	120145	900UF
C34	120146	1000UF
C35	120147	1100UF
C36	120148	1200UF
C37	120149	1300UF
C38	120150	1400UF
C39	120151	1500UF
C40	120152	1600UF
C41	120153	1700UF
C42	120154	1800UF
C43	120155	1900UF
C44	120156	2000UF
C45	120157	2100UF
C46	120158	2200UF
C47	120159	2300UF
C48	120160	2400UF
C49	120161	2500UF
C50	120162	2600UF
C51	120163	2700UF
C52	120164	2800UF
C53	120165	2900UF
C54	120166	3000UF
C55	120167	3100UF
C56	120168	3200UF
C57	120169	3300UF
C58	120170	3400UF
C59	120171	3500UF
C60	120172	3600UF
C61	120173	3700UF
C62	120174	3800UF
C63	120175	3900UF
C64	120176	4000UF
C65	120177	4100UF
C66	120178	4200UF
C67	120179	4300UF
C68	120180	4400UF
C69	120181	4500UF
C70	120182	4600UF
C71	120183	4700UF
C72	120184	4800UF
C73	120185	4900UF
C74	120186	5000UF
C75	120187	5100UF
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C87	120199	6300UF
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C90	120202	6600UF
C91	120203	6700UF
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C101	120213	7700UF
C102	120214	7800UF
C103	120215	7900UF
C104	120216	8000UF
C105	120217	8100UF
C106	120218	8200UF
C107	120219	8300UF
C108	120220	8400UF
C109	120221	8500UF
C110	120222	8600UF
C111	120223	8700UF
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C149	120261	12500UF
C150	120262	12600UF
C151	120263	12700UF
C152	120264	12800UF
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C154	120266	13000UF
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C158	120270	13400UF
C159	120271	13500UF
C160	120272	13600UF
C161	120273	13700UF
C162	120274	13800UF
C163	120275	13900UF
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C180	120292	15600UF
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C370	120482	34600UF
C371	120483	





AMP# 28-4101-8P
BATTING COMB
AMP# 28-4201-8S

P1	5	1
GROUND	6	2
P- INPUT	7	3
	8	4

AMP# 28-4102-8P
AMP# 28-4202-8P
AMP# 28-4302-8P

P2	5	1
OUTPUT	6	2
O P COM	7	3
P R C D	8	4
A C L O R		

NOTE CONNECTION KEYING

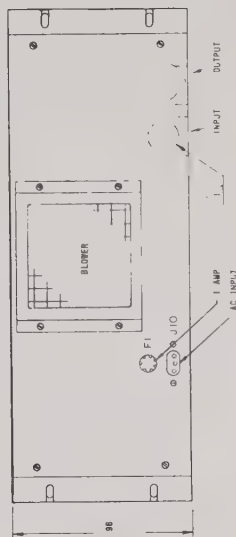
DETAIL 'A'

RYLINE TYPICAL OF
DANA CORD SET
NO 407448 MAC DANA
COST PART NO
2802 7 ENCLOSURE

QTY	DANA	NOMENCLATURE OR DESCRIPTION	CODE	SPECIFICATION
REQD	PART NUMBER	LIST OF MATERIAL OR PARTS LIST	IDENT	OR VENDOR P. N. NO
UNLESS OTHERWISE SPECIFIED				
TOLERANCES UNLESS INDICATED				
FRACTIONS ANGLES				
MATERIAL				
FINISH				
APPLICATION				
UTP REQD				
NEXT ASSY				
USED ON				
NA - FA				
407418 2860				
D 21792				
SIZE CODE IDENT NO				
4526-18				
SCALE				
WT				
SHEET 1 OF 1				

QTY	DANA	NOMENCLATURE OR DESCRIPTION	CODE	SPECIFICATION
REQD	PART NUMBER	LIST OF MATERIAL OR PARTS LIST	IDENT	OR VENDOR P. N. NO
UNLESS OTHERWISE SPECIFIED				
TOLERANCES UNLESS INDICATED				
FRACTIONS ANGLES				
MATERIAL				
FINISH				
APPLICATION				
UTP REQD				
NEXT ASSY				
USED ON				
NA - FA				
407418 2860				
D 21792				
SIZE CODE IDENT NO				
4526-18				
SCALE				
WT				
SHEET 1 OF 1				

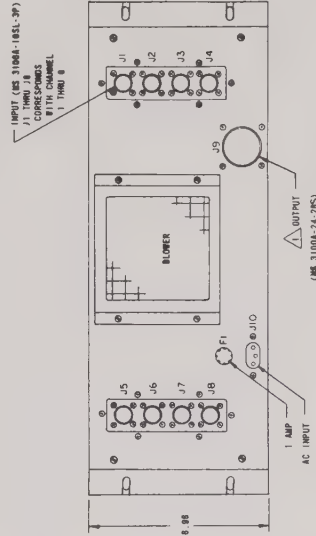
NOTE: UNLESS OTHERWISE SPECIFIED



QTY REQD	DRAW PART NUMBER	NOMENCLATURE OR DESCRIPTION	DATE IDENT	REVISION OR VERSION P/N	FIG
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS FRACTIONS DECIMALS ANGLES RADIUS DIA					
MATERIAL		CONTRACT NO.	DANA LABORATORIES INC. IRVINE, CALIFORNIA		
FINISH		OUTLINE DIMENSIONAL ENCLOSURE MODEL 2-08-1	SIZE CODE (REF NO) Dwg No. 32402		
QTY REQD	PA	QTY REQD	WT	SHEET	OF
NEED ASSY	USED ON	APPLICATION			

PIZZA HUT 8101 W. FLORISSANT AVE. SUITE 1000 DENVER, CO 80231
 1-800-333-3333

NOTE: UNLESS OTHERWISE SPECIFIED

[illegible]

Warranty

It is the practice of Dana Laboratories, Incorporated, to manufacture only products of a quality that will merit customer satisfaction. The company recognizes that customer satisfaction is achieved, not only by delivering products meeting advertised performance specifications and having a high level of reliability, but also by honestly and efficiently fulfilling their warranty obligations as set forth below.

Dana Laboratories, Inc., agrees to correct, either by repair or replacement, any defect of material or workmanship in Dana-manufactured units or components which develop within one year after delivery of the equipment to the original purchaser — provided that the equipment has been subjected only to normal and proper use.

In the event of failure of any component delivered with Dana equipment, but not manufactured by Dana Laboratories, assistance will be given the customer in obtaining, from the original manufacturer, reasonable adjustment under that manufacturer's warranty.

Any item claimed to be defective during the warranty period must be returned to Dana Laboratories, Inc., with transportation charges prepaid. The item will be repaired and returned to the purchaser with return transportation prepaid by Dana unless, of course, the item is found not to be defective or found to be damaged by misuse — in which case it will be returned to the purchaser with repair and transportation billed collect.

DANA

W. H. H. H.

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The second volume of the history of the American people, from the first settlement of the continent to the present time, is a work of great interest and value. It is a work of great interest and value. It is a work of great interest and value.

The third volume of the history of the American people, from the first settlement of the continent to the present time, is a work of great interest and value. It is a work of great interest and value. It is a work of great interest and value.

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